Project Report: Exploring Mars for Past or Present Life

Lead Team:	***Arizona State University***
Project Title:	***Exploring Mars for Past or Present Life***
Project Investigators:	***Philip Christensen, Jack Farmer, Ronald Greeley***

Project Progress

Mars Global Surveyor Thermal Emission Spectrometer (TES) data continue to provide new information pertinent to the role of water in mineralogical processes on Mars. Although no large−scale carbonate deposits have yet been detected, spectral evidence has been observed for H2O bearing minerals in Martain dust. Newly observed spectral details of the dust indicate that zeolites are a possible candidate for the aqueous mineral component. A search for spectral matches to the SNC or Martian meteorites yielded positive results. An excellent match with the spectrum of the ALH84001 meteorite was found in Eos Chasma within the Valles Marineris. (Eos chasma had been previously short−listed as a potential landing site for the 2003 Mars Exploration Rover (MER) rover mission). An important result of this work is that very little of the current surface of Mars matches the spectral character of the SNCs, possibly indicating a change in magmatic processes over Martian geologic history. TES data continue to be used to refine the candidate landing sites for the 2003 MER mission. The Sinus Meridiani hematite deposit, discovered with TES data, remains a top choice for one of the two rovers. Newly acquired Mars Odyssey Thermal Emission Imaging System (THEMIS) images also are being used to characterize the candidate landing sites. The geologic details of the hematite site are revealed with stunning clarity using the infrared images produced by THEMIS, putting into context the geologic setting of the hematite deposit.

Building on postdoctoral studies of collaborator Jeff Moersch, Masters student Alice Baldridge (Advisor Farmer) developed detailed mineralogical ground truth for remotely sensed Mars analog sites in the Badwater Basin of Death Valley. In collaboration with Moersch, we used spectral mapping tools (Environment for Visualizing Images (ENVI)) to analyze MODIS ASTER instrument (MASTER) (mid−infrared spectral) scenes and identify the locations of pure end−member pixels. To establish ground truth, we sampled all of the pure end member carbonate, sulfate and silicate pixels for laboratory analysis of mineralogy. We then applied a number of methods (X−ray diffraction (XRD), microprobe, SEM/EDS, thin section petrography and point counting), and lab

spectral analysis (using the TES analog instrument), plus ground−based spectroscopy to identify mineralogy. To aid in spectral identifications, we developed a mid−infrared (IR) spectral library for evaporates. This information was added to ASU's Spectral Library for use by the TES and THEMIS project teams who are presently mapping Mars. This spectral library also included mineralogical information from XRD, microprobe, EDS/SEM and basic petrographic descriptions. The results of the ground truth study were presented at Geological Society of America (GSA) and American Geophysical Union (AGU) meeting last Fall, and they comprised a Master's thesis completed by Alice Baldridge in the Spring. The results of this study established thresholds for the detection of evaporite minerals (especially carbonates, sulfates and silicates) in the Badwater Basin. The results of the study suggest that at the coarse spatial of the TES instrument (3 km/pixel), detection of carbonates and sulfates would be unlikely. However, at the enhanced spatial resolution of THEMIS (100 m/pixel), both carbonates and sulfates should be easily detected, provided they are present at abundances exceeding ~15%. The results of this two part study are currently being prepared for publication with a planned submission in the Fall.

Under the direction of Co−I Farmer, Masters student Meredith Payne has used Viking and Mars Observer Camera (MOC) imaging to identify a half dozen sites adjacent to the North Polar cap of Mars, where very recent volcano−ice interactions and associated hydrothermal processes appear to have operated. Integrated data sets from Viking, the MOC and the Mars Observer Laser Altimeter (MOLA) were used to construct geologic maps, topographic profiles of suspect volcanic features and three−dimensional Digital Elevation Models (DEMs) of sites using ARC Info, ARC View and other analytical tools. We tested alternative hypotheses for the origin of the suspect volcanic and hydrothermal landforms at each site using morphometric comparisons with terrestrial analogs of known origin in Iceland, western North America and Arizona. Results of the study were presented at the GSA/Geological Society of London (GSL) meeting in Edinburgh last summer and at the GSA and AGU meetings last Fall, and they comprise a Masters thesis to be completed by Meredith Payne in late July.

Highlights

- Using TES data, several sites were discovered on the surface of Mars that contain signatures for coarse−grained (specular) hematite, a mineral that only forms on earth in the presence of large amounts of water. Sites of specular hematite enrichment were previously suspected of having sustained aqueous processes based on geomorphic features. Because of its high scientific interest and safe landing conditions, the hematite site at Sinus Meridiani has been short−listed as a top landing site for one of the 2003 MER rovers.

- Mars surface dust appears to contain an aqueous alteration mineral, possibly some form of zeolite.

- A spectral match for the Martian meteorite ALH84001 was discovered in a region of Valles Marineris previously targeted as a potential

landing site for the 2003 MER mission.

- Remote sensing analog studies in the Badwater Basin, Death Valley, have revealed new insights about infrared spectral mapping of evaporite minerals of importance in detecting such minerals from Mars orbit using current and future generations of spectral mapping instruments.

- Evidence for recent volcanic activity in polar regions of Mars suggests the possibility for near surface hydrothermal systems and recent habitable zones of liquid water for sustaining extant Martian life.

Roadmap Objectives

- ***Objective No. 8:*** Past Present Life on Mars

Mission Involvement

Mission Class*	***Mission Name (for class 1 or 2) OR Concept (for class 3)***	***Type of Involvement***
1	Mars Global Surveyor	PI Christensen, TES instrum/payload devel
1	Mars Odyssey	PI Christensen THEMIS instrum/payload devel
2	MER 2003	PI Christensen Mini−TES instrum/payload devel
2	MER 2003	Participating Scientist Greeley; Data analysis
2	MER 2003	Participating scientist Farmer; Data analysis
3	Mars Recon Orbiter	Science Definition Team, Farmer; Planning sup
3	'09 Smart Lander	MEPAG Farmer, Greeley; Planning support

* Mission Class: Select 1 of 3 Mission Class types below to classify your project:
1. Now flying OR Funded & in development (e.g., Mars Odyssey, MER 2003, Kepler)
2. Named mission under study / in development, but not yet funded (e.g., TPF, Mars Lander 2009)
3. Long−lead future mission / societal issues (e.g., far−future Mars or Europa, biomarkers, life definition)

** Type of Involvement = Role / Relationship with Mission
Specify one (or more) of the following: PI, Co−I, Science Team member, planning support, data analysis, background research, instrument/payload

development, research or analysis techniques, other (specify).

PI Christensen is the lead on three instruments on current or planned missions: the TES instrument on Mars Global Surveyor, the THEMIS instrument on Odyssey, and the Mini−TES instrument on MER. Data from these instruments are important for identifying the mineralogical signature of water on Mars. Greeley is the former Chair of the Mars Exploration Payload Assessment Group (MEPAG), the primary community−based science strategy group for the Mars Program. Farmer is the current MEPAG Chair, Chair of the NAI Mars Focus Group and the interim Chair of MEPAG's Astrobiology Science Steering Group. Farmer is also a member of NASA's Space Sciences Advisory Group. Greeley and Farmer are also members of the Mars Exploration Review Team (MERT) and MAST (Mars Ad Hoc Science Team), both oversight committees for the Mars Exploration Program. Farmer represented Astrobiology and Solar System exploration in a congressional hearing last summer on the search for extraterrestrial life. Greeley and Farmer are also members of the Mars Exploration Rover Mission that will be launched next year.

Field Expeditions

Field Trip Name: Badwater Basin, Death Valley	
Start Date: 05/01/2001	***End Date:*** 11/01/2001
Continent: North America	***Country:*** USA
State/Province: California	***Nearest City/Town:*** Furnace Creek, CA
Latitude:	***Longitude:***
Name of site(cave, mine, e.g.): Badwater Basin	***Keywords:*** Remote sensing, infrared spectroscopy, mineral mapping, evaporite basin, sulfates, carbonates, silicates, Mars, Death Valley, Badwater Basin
Description of Work: Collect samples and spectra to determine ground truth mineralogy at sites pre−selected as mineralogical end members using mid−IR remote sensing spectral mapping data (MASTER) processed with ENVI.	
Members Involved: Jack Farmer, Alice Baldridge, Jeffrey Moersch, Phil Christensen	

Cross Team Collaborations

We have interacted with Paul Knauth of the ASU team on applications of his work to Mars.